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Critical Factors Related to Student Success Technology

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***Abstract*—This study examines university students' perspectives on student success technology. Efforts to improve graduation and retention rates for undergraduates (i.e. "student success") and initiatives to enhance the overall student experience, are critical for higher education administrators, faculty and staff. These actors are significantly dependent on technology and technology-mediated services. To help understand student perspectives on online services related to student success, this study uses data from a 2016 survey of Portland State University students about the importance and satisfaction that students placed on accomplishing key tasks online (n=1,190 respondents). The main questions in this inquiry are: 1. What, if any, factors, or latent variables, are in the data set?; 2. If there are latent variables, what might they tell us about students' perspectives on accomplishing critical online tasks? The study's main findings are that five factors - navigation, tactical, funding, personalization and planning - are present in the data and statistically significant. The findings also suggest that a sixth factor, funding, is not significant. This study contributes to the literature by supporting the notion that there is harmony between the technology that universities utilize to support students and the value that students derive from such tools.**

I. Introduction

This study examines data related to university students' perspectives on student success technology and uses factor analysis to understand how variables in the dataset are related to factors, or latent variables. Student success technology is technology that students can use to support their own continued enrollment, and technology for faculty and staff to use to support improving retention and graduation rates (i.e. "student success"), primarily for undergraduates.

Student success technology (often referred to as Integrated Planning and Advising for Student Success [iPASS] systems) is a large subset of administrative e-services and is related to supporting undergraduates with persisting and ultimately graduating from college [1]. Student success technology focuses on providing real-time and proactive support for students, such as communication campaigns delivered via email, SMS for coaching and advising, and mobile app notifications to support students in completing critical administrative tasks (e.g. resolving account holds that prevent registration). Student success technology can include the following: degree audit tools; degree planning or mapping tools; online self-service tools for student business; early-alert systems to catch academic troubles; and "digital tools that keep a record of services used, advice given, or decisions made" [2].

This study is related to upcoming research which will develop a research model to understand student adoption of student success technology (i.e. higher education e-services). The model will consist of factors (each consisting of numerous indicators) and will be based on a literature review, focus groups, expert panel and accepted adoption models. Based on the model, a survey of students will be conducted to understand their perceptions on adoption, and then the validity of the model will be tested by using structural equation modeling (SEM). A key part of SEM is factor analysis, where confirmatory factor analysis is used in relation to the measurement model [3]. Thus, learning about factor analysis is critical preparation for SEM.

This study uses data from a 2016 survey of Portland State University (PSU) students about the importance and satisfaction that students placed on accomplishing key tasks online, which has a sample of graduates, undergraduates and post-baccalaureate students (n=1,190 respondents). The main questions this inquiry examines are: 1. What, if any, factors, or latent variables, are in the data set?; 2. If there are latent variables, what might they tell us about students' perspectives on accomplishing critical online tasks?

More broadly, this study seeks to contribute to knowledge at the intersection of e-services/digital services adoption by college students, higher education sector strategies related to effectively leveraging technology to improve student retention and graduation rates (primarily focused on undergraduates), and goals to improve the student experience for students at all class levels. Student success efforts are critical as the United States seeks to improve college attainment [4], [5].

II. Literature Review

In an effort to anchor this study and situate student success technology within the broad ecosystem of services and technologies that universities use, it is helpful to consider the relationship between e-services and student success technology, since so little relative research exists on student success technology [1]. As so little research exists on student success technology, this study helps inform the development of the field.

Per Bittner and Brown, services are "deeds, processes and performances...provided to customers in exchange relationships among organizations and individuals" [6]. Defined in a higher education context - and drawing from definitions of e-services in the public sector literature [7], e-commerce literature [8], and higher education [9], [10] - e-services are information and communication technologies to enable web-based service delivery that seamlessly bring together distributed resources to enable complex transactions.

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E-services provide higher education institutions with the ability to improve the efficiency and effectiveness with which services are provided to students, employees, the public, community partners and other stakeholders.

Building on this definition, e-services in higher education can be categorized into two broad camps - e-learning and administrative services. While very little research exists on administrative e-services, fairly extensive research exists on student and faculty adoption of e-learning [11], learning management systems [12] and m-learning (mobile learning) [13]. E-learning services consist of a continuum of enhanced, blended and online learning [14] that uses electronic technologies to deliver educational curriculum outside of a physical (i.e. traditional) classroom [15].

In contrast, administrative e-services are e-services that students use when accomplishing tasks related to maintaining their enrollment, and they are largely undefined [16]. These services include items such as scheduling advising appointments, paying bills, applying for financial aid, signing up for campus clubs, finding on-campus parking, applying for scholarships, applying for admission and accessing academic supports [17], [18]. They are often accessed via web applications [10] or are often delivered through critical Enterprise Resource Planning systems [19], [20], which are often legacy systems that are challenged in our mobile-first world [21], and are generally replacing high-touch human service delivery [22].

Administrative e-services and student success technology are closely related. While the technologies that underpin administrative e-services and student success technology are very similar, the end goals that the technologies enable, i.e. how the technology is utilized, are different. Administrative e-services focus on maintaining enrollment, and student success technology's goals, while including maintaining enrollment, are more specific, with explicit end goals of helping students persist and graduate, and student success technology includes creating ecosystems of tools that are intentionally leveraged together [23].

III. Factor Analysis

Factor analysis is an "interdependence [statistical] technique whose primary purpose is to define the underlying structure among the variables in the analysis" [24]. In this technique, a factor consists of a group of variables that are "highly interrelated" and as such, it enables researchers to examine a large number of variables [24]. "It is hoped, generally, that the k constructs will explain a good portion of the variance in the original j × j matrix of associations (e.g., correlation matrix) so that the constructs, or factors, can then be used to represent the observed variables" [25]. For example, one might be interested in studying leadership, but there could be many variables that relate to leadership. Factor analysis could be used to identify groups of interrelated variables that help to measure components of leadership.

Two primary approaches to factor analysis are exploratory factor analysis (EFA) and confirmatory factor analysis (CFA). EFA is used to identify the factors, or latent variables, for a group of variables and is used to "generate theory" [25] when there is little knowledge about how variables could be related [26]. Generating meaning from factors hinges on a researcher's perspective and as such is subjective [25]. On the other hand, CFA is used to test a theory when a strong rationale for the factors and variables that define each factor are known [25], [24]. In CFA, "the researcher's a priori assumption is that each factor is associated with a specified subset of indicator variables" [3]. There are two majors methods of extracting factors from a set of variables. Principal components analysis (PCA), or "components analysis," is most commonly used in EFA, and principal factor analysis (PFA), which is used in confirmatory research and also for CFA in structural equation modeling [3].

Structural equation modeling is a comprehensive statistical technique in which a series of dependent relationships can be examined simultaneously, including the examination of the relationships between independent variables [24], [27]. For example, if one hypothesizes that a variable can be both a dependent and independent variable in the same theory, SEM can be used to evaluate such a hypothesis [24]. Additionally, SEM accommodates multiple latent independent variables, where each latent variable can be defined by multiple indicators [28]. SEM is considered a second-generation technique and there are two types: covariance-based SEM (CB-SEM), which is primarily used to confirm theories "(i.e., a set of systematic relationships between multiple variables that can be tested empirically") and partial least squares structural equation modeling (PLS-SEM), which is used primarily to develop theories in exploratory research [26].

This study uses PCA, as the primary purpose of the study at hand is to examine a larger set of variables to see if there are factors that explain latent variables.

IV. Data and Methods

The data used in this study are from the Redesign myPSU student survey, which was administered to understand the importance and satisfaction that Portland State University (PSU) students placed on accomplishing key tasks online through the myPSU website and PSU digital services, such as applying for scholarships, easily identifying and purchasing books and course materials, and quickly finding classes using an online map. Distributed by Portland State University's Office of Academic Affairs with assistance from the Portland State Survey Research Lab, the survey was emailed to a randomly generated list of 8,500 Portland State University students (undergraduates, graduates, post-baccalaureate) on May 26, 2016 and remained open through May 31, 2016. The sample size is 1,190 respondents.

This study focuses on all students who responded, which includes undergraduates, graduates and post-baccalaureate students from across the University. 34 variables from the survey are used in this study: 17 variables related to the importance of student success technology and 17 variables related to satisfaction with student success technology (see Table 1 below). Two analytic samples (subpopulations of the data set on which analyses were performed) were created for this

study: one analytic sample that excludes cases who were missing on more than 40% of the 17 importance variables; one analytic sample that excludes cases who were missing on more than 40% of the 17 satisfaction variables.

TABLE I. **IMPORTANCE AND SATISFACTION VARIABLES**

Importance variables	Satisfaction variables
Importance visual representation of where in degree.	Satisfaction visual representation of where in degree.
Importance easily applying for scholarships	Satisfaction easily applying for scholarships
Importance seeing all important deadlines and next steps in one place.	Satisfaction seeing all important deadlines and next steps in one place
Importance easily finding internships related to major.	Satisfaction easily finding internships related to major.
Importance seeing incoming messages from PSU inboxes one place	Satisfaction seeing incoming messages from PSU inboxes one place
Importance easily identifying and purchase books and course materials	Satisfaction easily identifying and purchase books and course materials.
Importance quickly finding map to classes	Satisfaction quickly finding map to classes
Importance seeing how much owe one academic year	Satisfaction seeing how much owe one academic year
Importance easily finding course descriptions	Satisfaction easily finding course descriptions
Importance searching PSU resources quality results	Satisfaction searching PSU resources quality results
Importance view opportunities to engage with campus based on major and interests	Satisfaction view opportunities to engage with campus based on major and interests
Importance conducting all important PSU business through one site and one login	Satisfaction conducting all important PSU business through one site and one login
Importance accessing and using PSU online resources and services from a mobile device	Satisfaction accessing and using PSU online resources and services from a mobile device
Importance personalized experience when using PSU online resources.	Satisfaction personalized experience when using PSU online resources.
Importance easily view class schedule online.	Satisfaction easily view class schedule online.
Importance easily get to PSU online services from one place.	Satisfaction easily get to PSU online services from one place.

V. DATA ANALYSIS

In this study, Stata 15.1 was used to conduct the factor analysis. Factors were extracted using principal components analysis (PCA), which is the pcf/principal-component factor function in Stata [3]. A VARIMAX rotational approach was used, in order to facilitate interpretation (i.e. maximizing a variable's loading on a single factor, as well as making the number of high loadings as few as possible), as the orthogonal rotation methods, of which VARIMAX is one, are useful for data reduction purposes [24]. Factors that had an eigenvalue (variance of the factor) of greater than 1 were selected/retained, as this is a general rule of thumb for choosing the number of factors [24]. Then, the variables within each factor that had rotated factor loadings of greater than 0.50 were grouped together to create the factors. Factor loadings "represent the correlation between an original variable and its factor" and loadings of plus or minus 0.50 or greater are "considered practically significant" [24]. These factors were then named. The factor scores (for cases that were part of the analytic samples) were computed for each variable and then regressions were run to test the significance of the factors.

VI. RESULTS

The results of the data analysis are described in this section, factor loadings are in Tables II and III below. For the importance variables, three factors were identified and for the satisfaction variables, two factors were identified. Then, factor loadings were used to group and facilitate the naming of the factors. Table IV, below, shows the factors that were named as a result of the above factor loadings analysis process.

TABLE II. FACTOR LOADINGS FOR IMPORTANCE VARIABLES

Variable description	Factor 1	Factor 2	Factor 3	Uniqueness
Importance visual representation of where in degree.	0.2223	0.1953	0.4843	0.6779
Importance easily applying for scholarships	0.0496	0.0609	0.822	0.3181
Importance seeing all important deadlines and next steps in one place.	0.2414	0.308	0.5665	0.526
Importance easily finding internships related to major.	0.0772	0.117	0.7473	0.4219
Importance seeing incoming messages from PSU inboxes one place	0.3495	0.5645	0.1421	0.539
Importance easily identifying and purchase books and course materials	0.1911	0.7177	0.0817	0.4417
Importance quickly finding map to classes	0.039	0.6873	0.2523	0.4624
Importance seeing how much owe one academic year	0.1584	0.6814	0.186	0.476
Importance easily finding course descriptions	0.3357	0.442	0.2739	0.6169
Importance searching PSU resources quality results	0.267	0.3282	0.4232	0.6419
Importance view opportunities to engage with campus based on major and interests	0.7428	0.0933	0.154	0.4159
Importance conducting all important PSU business through one site and one login	0.6616	0.0832	0.2382	0.4986
Importance accessing and using PSU online resources and services from a mobile device	0.5671	0.2715	0.2721	0.5306
Importance personalized experience when using PSU online resources.	0.4052	0.5531	0.098	0.5202
Importance easily view class schedule online.	0.7201	0.2679	0.0103	0.4096
Importance easily get to PSU online services from one place.	0.4409	0.4233	0.2941	0.5398
Importance being notified of important deadlines and next steps related to business	0.5698	0.3468	0.0717	0.5499

TABLE III. FACTOR LOADINGS FOR SATISFACTION VARIABLES

Variable description	Factor 1	Factor 2	Uniqueness
Satisfaction visual representation of where in degree.	0.4055	0.6562	0.405
Satisfaction easily applying for scholarships	0.2053	0.8009	0.3164
Satisfaction seeing all important deadlines and next steps in one place	0.4715	0.6294	0.3816
Satisfaction easily finding internships related to major.	0.1764	0.8097	0.3132
Satisfaction seeing incoming messages from PSU inboxes one place	0.5754	0.2903	0.5846
Satisfaction easily identifying and purchase books and course materials.	0.6015	0.3518	0.5144
Satisfaction quickly finding map to classes	0.5351	0.4029	0.5513
Satisfaction seeing how much owe one academic year	0.4724	0.4942	0.5326
Satisfaction easily finding course descriptions	0.4605	0.6207	0.4026
Satisfaction searching PSU resources quality results	0.3416	0.6935	0.4024
Satisfaction view opportunities to engage with campus based on major and interests	0.6777	0.3235	0.4361
Satisfaction conducting all important PSU business through one site and one login	0.6022	0.4124	0.4672
Satisfaction accessing and using PSU online resources and services from a mobile device	0.5723	0.4896	0.4327
Satisfaction personalized experience when using PSU online resources.	0.7848	0.1514	0.3611
Satisfaction easily view class schedule online.	0.805	0.1905	0.3157
Satisfaction easily get to PSU online services from one place.	0.5907	0.5139	0.387
Satisfaction being notified of important deadlines and next steps related to business.	0.588	0.4103	0.486

TABLE IV. FACTORS IDENTIFIED IN THIS STUDY

Importance factors

Factor 1 - *Navigation*

- Importance view opportunities to engage with campus based on major and interests
- Importance conducting all important PSU business through one site and one login
- Importance accessing and using PSU online resources and services from a mobile device
- Importance easily view class schedule online.
- Importance being notified of important deadlines and next steps related to business

Factor 2 - *Tactical*

- Importance seeing incoming messages from PSU inboxes one place
- Importance easily identifying and purchase books and course materials
- Importance quickly finding map to classes
- Importance seeing how much owe one academic year
- Importance personalized experience when using PSU online resources.

Factor 3 - *Funding*

- Importance easily applying for scholarships
- Importance seeing all important deadlines and next steps in one place.
- Importance easily finding internships related to major.

Satisfaction factors

Factor 1 - *Personalization*

- Satisfaction seeing incoming messages from PSU inboxes one place
- Satisfaction easily identifying and purchase books and course materials.
- Satisfaction quickly finding map to classes
- Satisfaction view opportunities to engage with campus based on major and interests
- Satisfaction conducting all important PSU business through one site and one login
- Satisfaction accessing and using PSU online resources and services from a mobile device
- Satisfaction personalized experience when using PSU online resources.
- Satisfaction easily view class schedule online.
- Satisfaction easily get to PSU online services from one place.
- Satisfaction being notified of important deadlines and next steps related to business.

Factor 2 - *Planning*

- Satisfaction visual representation of where in degree.
- Satisfaction easily applying for scholarships
- Satisfaction seeing all important deadlines and next steps in one place
- Satisfaction easily finding internships related to major.
- Satisfaction easily finding course descriptions
- Satisfaction searching PSU resources quality results
- Satisfaction easily get to PSU online services from one place.

In order to assess the significance of the factors, and the relationships between them, five multiple regressions were computed: two relating the satisfaction factors (as dependent variables) with the importance factors (as independent variables) and three relating the importance factors (as dependent variables) with the satisfaction variables (as independent variables). Tables V and VI, below, show the variables used in the models and the multiple regression results. In summary, four of the five regression models were significant.

TABLE V. VARIABLES AND FACTOR NAMES

	Variable	**Factor name**
Importance variables	Factor1_imp	Navigation
	Factor2_imp	Tactical
	Factor3_imp	Funding
Satisfaction variables	Factor1_satis	Personalization
	Factor2_satis	Planning

TABLE VI. REGRESSION MODELS AND RESULTS

Regression model	**Model**	**Results**
Model #1	Personalization (factor1_satis) = Navigation (factor1_imp) + Tactical (factor 2_imp) + Funding (factor3_imp)	Overall model is significant at the p<0.001 level; navigation and tactical are significant at the p<0.001 level; funding is not significant, with p=0.899.
Model #2	Planning (factor2_satis) = Navigation (factor1_imp) + Tactical (factor 2_imp) + Funding (factor3_imp)	Overall model is significant at the p<0.01 level; navigation is not significant, p=0.062; tactical is significant at the p<0.01 level; and funding is not significant, with p=0.889.
Model #3	Navigation (factor1_imp) = Personalization (factor1_satis) + Planning (factor2_satis)	Overall model is significant at the p<0.001 level; personalization is significant at the p<0.001 level; planning is not significant, with p=0.891.
Model #4	Tactical (factor2_imp) = Personalization (factor1_satis) + Planning (factor2_satis)	Overall model is significant at the p<0.001 level; personalization is significant at the p<0.001 level; and planning is significant at the p< 0.01 level.
Model #5	Funding (factor3_imp) = Personalization (factor1_satis) + Planning (factor2_satis)	Overall model is not significant, with p=0.9615.

In looking at the regression results, it is helpful to attempt to explain what the significant relationships might mean. In Model 1, navigation, tactical and funding all relate positively to personalization (overall model is significant at the p<0.001 level; navigation and tactical are significant at the p<0.001 level; funding is not significant, with p=0.899). This could be interpreted to mean that the degree to which a student is satisfied about the personalization of their experiences relates to the importance they place on navigation in their digital college experience, completing tasks online and identifying funding and finding internships to support their education. This makes sense in that the higher importance a student places on these kinds of online tasks, the more a student might be satisfied with the degree of personalization.

Model 2 suggests that the satisfaction a student experiences in terms of planning is related to the importance a student places on navigation, tactical and funding (overall model is significant at the p<0.01 level; navigation is not significant, p=0.062; tactical is significant at the p<0.01 level; and funding is not significant, with p=0.889) - all of the independent variables relate positively to planning. From one perspective, at least, this makes sense: in order to be satisfied with planning, a student might place a high importance on forward-looking tasks, such as navigating through the university, completing tasks, and identifying funding, all of which enhance planning when they are done proactively.

In Model 3, satisfaction with personalization and satisfaction with planning positively relate to the importance placed on navigation (overall model is significant at the p<0.001 level; personalization is significant at the p<0.001 level; planning is not significant, with p=0.891). These results suggest that at least in this case, satisfaction could predict importance, meaning that if a student is more satisfied with the ability to have a personalized experience and more satisfied with the ability to plan, a student could believe that navigation has a higher degree of importance. Intuitively, this can make sense, as planning implies finding an individualized or personalized path, and when a student is more satisfied with an individualized path, a student might place more importance on the "how" of curating this individualized path, i.e. navigation.

In Model 4, personalization and planning related positively to tactical (overall model is significant at the p<0.001 level; personalization is significant at the p<0.001 level; and planning is significant at the p< 0.01 level). These results also suggest that at least in this case, satisfaction could predict importance, meaning that if a student is more satisfied with the ability to have a personalized experience and more satisfied with the ability to plan, a student could believe that completing tasks, i.e. taking action on outstanding items, has a higher degree of importance. Viewed from one perspective, being more satisfied with an individualized path (i.e. conceiving of personalization and planning together) implies that a student places more importance on accomplishing tasks, in that it would be incredibly difficult to create an individualized path or experience without taking action. Model 5, relating satisfaction with personalization and satisfaction with planning to the importance of funding, is not significant (overall model has a p-value of 0.9615). This should not be surprising as funding was not significant in any of the

models, whether it was used as a dependent variable or an independent variable.

VII. Conclusion

This study attempted to contribute to knowledge related to e-services/digital services adoption by college students and higher education sector strategies about how to most effectively leverage technology to improve undergraduate retention and graduation rates. Student success efforts are critical as universities in the United States seek to improve college graduation rates and meet workforce and other societal demands. This study examined two primary questions: 1. What, if any, factors, or latent variables, are in the data set?; 2. If there are latent variables, what might they tell us about students' perspectives on accomplishing critical online tasks?

In response to the first question, it is clear that latent variables exist in the data set for questions related to importance and satisfaction. The five significant latent variables are navigation, tactical, funding, personalization and planning. In relation to the second question, the results of the regression models, which were based exclusively on the factors/latent variables, suggest that navigation, tactical, personalization and planning are significant in understanding students' perspectives on accomplishing online tasks. However, the results suggest that funding is not significant.

The implications of the findings from this study are that there is some evidence of the centrality of navigation, tactical, personalization and planning in common conceptions of student success technology. Student success technology (often referred to as Integrated Planning and Advising for Student Success [iPASS] systems) can include degree audit tools; degree planning or mapping tools; online self-service tools for student business; early-alert systems to catch academic troubles; and "digital tools that keep a record of services used, advice given, or decisions made" [2]. There are strong synergies between the latent variables in this study and the suite of tools commonly accepted to support student success efforts.

Some limitations of this study merit mention. First, the factors were difficult to define and this lack of concise definition likely influenced the results. In some cases, there were variables with high factor loadings that were not entirely related. For example, the personalization factor included a variable about the satisfaction of getting to PSU online services from one place and a variable about easily purchasing books and course materials. Second, factor analysis is inherently subjective and this can introduce significant bias [25].

In closing, this study attempted to provide a useful lens to more rigorously understand students' experiences with student success technology. It also helps inform upcoming research to use CFA and SEM to evaluate and develop a research model related to student success technology.

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